

Epidemic of Type 3 Paralytic Poliomyelitis in Baltimore, Maryland, 1960

GLEN E. GRESHAM, M.D., J. MEHSEN JOSEPH, Ph.D., ROBERT E. FARBER, M.D., and
CHARLOTTE SILVERMAN, M.D.

IN 1960, Baltimore City experienced an epidemic of paralytic poliomyelitis due predominantly to type 3 poliovirus. With 97 cases and a paralytic attack rate of 10.3 per 100,000 population, this was one of the major urban outbreaks in the United States in recent years and the largest shown to be type 3 in origin. Because of persistent interest in differences between poliomyelitis epidemics which might be related to virus type, as well as to the varying virulence of strains within each type, the epidemic characteristics of the 1960 Baltimore outbreak are presented.

It has been postulated that type 3 poliovirus may behave in a distinctive manner. Speculation that it may tend to cause more severe disease than other types was originally advanced by Bodian (1) in 1951 in observations on the 1944 Baltimore epidemic. The relative severity of this particular outbreak was also noted by Lenhard (2). In 1956, Eklund and Larson (3)

reported a type 3 epidemic in a completely susceptible population on an Alaskan island. Only the bulbar form of paralytic involvement was seen, and illness occurred predominantly among children. They postulated that these characteristics were due to the virus type. A 1954 report by Malherbe (4) of a "silent epidemic" in South Africa described a single, fatal, bulbar case in a group of children infected with type 3 poliovirus.

With these questions in mind, Siedler and co-workers (5) studied their data on the 1957 type 3 outbreak in Washington, D.C., but they were unable to demonstrate either increased severity or an unusually high degree of bulbar involvement. They did find the highest risk to be in preschool children, but this has also been true of the major type 1 urban epidemics which have occurred since mass immunization began (6-11). The 1952 data of Shelokov and co-workers (12), gathered throughout the United States, showed essentially the same distribution by age and type of paralytic involvement for cases due to each of the three poliovirus types. In New Jersey in 1958, Dougherty and Faro (13) found no apparent difference in the degree of residual involvement in cases due to type 1 and type 3 poliovirus. Thus, no consistent pattern of epidemic type 3 paralytic poliomyelitis has yet been documented.

Another matter of recent concern in relation to type 3 poliomyelitis is the known low potency of the type 3 component of the Salk vaccine from 1955 to 1958 (14). Berkovich and associates (15) reported that 47 percent of Massachusetts' 137 paralytic cases in 1959 had been

Dr. Gresham, an officer of the Epidemic Intelligence Service, Communicable Disease Center, Public Health Service, was assigned to the Maryland State Department of Health in 1960-61. Dr. Joseph is chief of the division of virology, bureau of laboratories, and Dr. Silverman is chief of the office of planning and research, Maryland State Department of Health. Dr. Farber is assistant commissioner of health for preventive medicine, Baltimore City Health Department. Mr. Todd M. Frazier, Baltimore City Health Department, and Mr. Luther Frantz and Mr. Stefan Eichler, Maryland State Department of Health, provided statistical and laboratory assistance.

triply vaccinated and that 53 of the 55 cases with successful virus isolations were type 3. They felt that these findings suggested possible low effectiveness of the type 3 component of the vaccine. In contrast, the 1959 cases nationwide (6) and the outbreaks in Des Moines (9) and in Seattle (10), in all of which type 1 was predominant, showed a consistently high effectiveness for Salk vaccine in triply inoculated persons. Accordingly, the 1960 Baltimore data are also presented as a study of vaccine effectiveness against type 3 poliovirus, as seen in this particular community outbreak.

Methods

The data presented in this paper represent the final roster of reported paralytic poliomyelitis cases in Baltimore City in 1960, thoroughly reviewed and revised in an intensive surveillance program. Only paralytic cases are included. Information was obtained from hospital charts, home visits by local health department personnel, correspondence, followup evaluations by physicians and physiotherapists, and laboratory reports. It was collected and compiled in the division of epidemiology of the Maryland State Department of Health.

Initially unreported cases discovered through surveillance of general hospitals, virology laboratories, rehabilitation centers, and sources of financial assistance were investigated and the cases accepted if the attending physician had made the clinical diagnosis of paralytic poliomyelitis. All cases in which the diagnosis was subsequently changed, or laboratory or clinical evidence was incompatible, were dropped. Since 75 of the 97 cases were eventually seen by the infectious disease service of the Baltimore City Hospitals, a high degree of uniformity of clinical interpretation was possible.

Virus isolations from stool, nasopharyngeal, and cerebrospinal fluid specimens and serologic testing were performed in the laboratories of the Maryland State Department of Health, Baltimore City Hospitals, the University of Maryland School of Medicine, and the Sinai Hospital of Baltimore. In the first of these, where the majority of determinations were done, monolayer tissue cultures of monkey kidney epithelial cells and HeLa cells were used in

Table 1. Paralytic poliomyelitis attack rates, Baltimore City, Md., and other areas, 1960

Area	Population ¹	Number of cases	Attack rate per 100,000
Baltimore City.....	939, 024	97	10. 3
Suburban counties:			
Baltimore County..	492, 428	17	3. 5
Anne Arundel County.....	206, 634	6	2. 9
Howard County.....	36, 152	1	2. 8
Maryland.....	3, 100, 689	147	4. 7
United States.....	179, 323, 175	2, 218	² 1. 2

¹ 1960 census.

² Reference 25.

virus isolation. Specimens which failed to reveal the presence of cytopathic agents in tissue culture were subpassaged at least once before they were considered negative for enteroviruses. Virus isolates were identified by the neutralization test with hyperimmune monkey serum for the prototypic strains of poliovirus types 1, 2, and 3. A positive virus control was incubated with each typing. Acute and convalescent phase serums were titrated for neutralizing antibody, virus controls being included in each test series. The neutralizing antibody titer was determined as the reciprocal of the highest dilution of patient's serum at which a 2+ cytopathogenic effect was observed.

Description of the Epidemic

The Baltimore City cases constituted a localized urban outbreak, as shown by the sharp contrast between the paralytic attack rates for the city and those for the major surrounding counties, the State of Maryland, and the United States (table 1). The epidemic was the fourth with a gross paralytic attack rate of more than 10 per 100,000 to occur in Baltimore in the last 25 years and the first since the introduction of mass immunization. Baltimore's other recent major outbreaks were in 1941, 1944, and 1950.

The first case occurred in late July; the peak was reached the last week in September, and the epidemic then declined steadily, the last case occurring in late November. Although the peak was somewhat later than often seen, the seasonal pattern was not unusual for paralytic poliomyelitis in the United States.

Paralytic attack rates for each ward in the city, adjusted for age, reveal that the Baltimore outbreak was further localized to the inner

Table 2. Age-adjusted attack rates for paralytic poliomyelitis, by wards in Baltimore City, 1960

Ward No.	Population	Number of cases	Age-adjusted attack rate per 100,000
Baltimore City--	939, 024	97	10. 8
Inner Baltimore City-----	651, 410	90	13. 9
1-----	21, 185	1	4. 8
2-----	10, 401	2	22. 6
3-----	7, 610	3	34. 9
4-----	7, 966	1	8. 3
5-----	8, 703	2	22. 9
6-----	20, 645	7	34. 4
7-----	24, 749	5	20. 9
8-----	47, 610	9	16. 7
9-----	44, 612	7	17. 6
10-----	16, 604	4	22. 4
11-----	11, 546	0	0
12-----	34, 984	4	12. 8
13-----	37, 788	2	6. 2
14-----	22, 240	1	4. 5
15-----	78, 635	5	7. 3
16-----	51, 779	2	3. 7
17-----	13, 287	1	6. 9
18-----	15, 462	4	23. 2
19-----	20, 477	5	22. 1
20-----	46, 224	9	19. 2
21-----	13, 955	5	33. 0
22-----	6, 475	0	0
23-----	10, 159	0	0
24-----	14, 803	2	14. 5
25-----	63, 511	9	13. 0
Outer Baltimore City-----	287, 614	7	2. 7
26-----	86, 636	5	6. 0
27-----	166, 283	1	0. 6
28-----	34, 695	1	3. 9

city (table 2), which is characterized by crowding, poor housing, and low socioeconomic status. The rate for the inner city was 13.9 in contrast to a rate of 2.7 for the populous middle- and upper-class areas of the outer city. The outer-city rate was similar to the rates for the suburban counties. This picture conforms to the now well-documented shift to more underprivileged groups noted in major urban poliomyelitis epidemics in the United States during the past 5 years (6).

Another aspect of this change is the reversal of the former general trend toward higher white than nonwhite attack rates. In Baltimore in 1960, as in most recent major epidemics, the nonwhite population was more heavily affected, with a rate of 14.6 as opposed to 8.0 for the white population (table 3). This was the first time that the nonwhite rate in Baltimore exceeded the white rate in an epidemic year. However, the nonwhite rate has been consistently higher than the white in Baltimore since the introduction of the Salk vaccine, in contrast to a more varied pattern previously.

Socioeconomic status was apparently a major factor in the geographic and racial localization of the Baltimore epidemic. Dividing the city's population by census tracts into five equal parts representing five socioeconomic levels (based on median rental and home valuation figures from the 1960 census) demonstrates an inverse relationship between rising socioeconomic status and paralytic poliomyelitis attack rates (table 4). The rate decreases from 20.2 to 0.5 from the lowest to the highest fifths.

Table 3. Paralytic poliomyelitis attack rates, by age group and race, Baltimore City, 1960

Age group (years)	Total			White			Nonwhite		
	Population	Number of cases	Attack rate ¹	Population	Number of cases	Attack rate ¹	Population	Number of cases	Attack rate ¹
Total-----	939, 024	97	10. 3	610, 595	49	8. 0	328, 429	48	14. 6
0-4-----	102, 609	52	50. 7	54, 896	26	47. 4	47, 713	26	54. 5
5-9-----	90, 093	21	23. 3	49, 305	9	18. 3	40, 788	12	29. 4
10-14-----	81, 472	7	8. 6	48, 744	5	10. 3	32, 728	2	6. 1
15-19-----	65, 257	2	3. 1	41, 891	0	0	23, 366	2	8. 6
20-29-----	114, 046	6	5. 3	70, 338	4	5. 7	43, 708	2	4. 6
30 and over-----	485, 547	9	1. 9	345, 421	5	1. 4	140, 126	4	2. 9

¹ Per 100,000 population.

Distribution of the paralytic cases by age group shows a marked localization to the younger ages, especially children under 5 years, in both races (table 3). The white and non-white rates for children under 5 years were 47.4 and 54.5, respectively. This age distribution differs notably from that seen nationally before the use of mass immunization, when school-age children had the highest rates (16). There were instances, however, in the prevaccination era of higher rates in the younger age groups. The Baltimore epidemics of 1950 and 1953, for example, had age distributions similar to that of 1960, but in 1941 and 1944 the predominance in school-age children then expected was found.

The slightly higher rates in males often seen in large poliomyelitis epidemics (17) were not consistently found in the Baltimore epidemic. In the highest risk age group (under 5 years), the attack rates were 50.7 and 50.6 for males and females, respectively.

Table 4. Paralytic poliomyelitis attack rates, by socioeconomic group, Baltimore City, 1960

Socioeconomic fifths of the population ¹	Population	Number of cases	Attack rate ²
Total.....	939, 024	97	10. 3
I (lowest).....	183, 293	37	20. 2
II.....	186, 477	34	18. 2
III.....	190, 394	14	7. 4
IV.....	187, 368	11	5. 9
V (highest).....	185, 728	1	0. 5

¹ Based on data from the 1960 census.

² Per 100,000 population.

In 67 of the 97 paralytic cases, virus isolation was attempted. Poliovirus was isolated in 50 of these; 48 were type 3 and 2 were type 1. No type 2 poliovirus or any other enteroviruses were isolated from any paralytic poliomyelitis case. Thirty cases had paired serums tested for neutralizing antibodies. In 22 of these, a rise in titer to type 3 was found, of which 7 were fourfold or greater. The remaining eight pairs of serums had initial significant titers for types 3 or 1 which remained unchanged. These laboratory data were the basis for calling the Baltimore outbreak a type 3 epidemic.

Clinical Syndrome

The most noteworthy clinical feature of the paralytic poliomyelitis seen in the 1960 Baltimore epidemic was the high proportion of cases with bulbar disease, defined as all cases with involvement of one or more cranial nerves. Although considerable confusion surrounds the term "bulbar poliomyelitis," the Baltimore epidemic clearly showed an unusually high incidence of cases with cranial nerve involvement (table 5). There were 13 bulbar cases and 25 bulbo-spinal cases, for a total of 39 percent with bulbar involvement, which is well above the range of 10 to 15 percent usually expected (18).

Respiratory failure also was frequent, occurring in 20.6 percent of the patients. There were 6 deaths among the 97 patients. Both respiratory failure and fatality were greatest in the bulbo-spinal group as contrasted with

Table 5. Clinical syndrome, severity, and mortality in paralytic poliomyelitis cases, Baltimore City, 1960

Type of paralytic poliomyelitis	Total number of cases	Respiratory failure		Significant paralysis or dead 60 days after onset		Deaths	
		Number of cases	Percent of cases	Number of cases	Percent of cases	Number	Paralytic fatality ratio (percent)
Total.....	97	20	20. 6	50	51. 6	6	6. 2
Spinal (only spinal nerves).....	59	3	5. 1	35	59. 3	1	1. 7
Bulbar (only cranial nerves).....	13	3	23. 1	1	7. 7	1	7. 7
Bulbo-spinal (both cranial and spinal nerves).....	25	14	44. 0	14	56. 0	4	16. 0

Table 6. Paralytic poliomyelitis attack rates, by age group, race, and vaccination status, Baltimore City, 1960

Race and age group (years)	Total			Unvaccinated			One or two vaccinations			Three or more vaccinations		
	Population	Number of cases	Attack rate ¹	Population	Number of cases	Attack rate ¹	Population	Number of cases	Attack rate ¹	Population	Number of cases	Attack rate ¹
<i>Total</i>												
All ages.....	939, 024	97	10. 3	444, 464	46	10. 3	138, 167	21	15. 2	356, 393	30	8. 4
0-4.....	102, 609	52	50. 7	16, 418	23	140. 1	25, 554	17	66. 5	60, 637	12	19. 8
5-9.....	90, 093	21	23. 3	7, 853	8	101. 9	13, 478	2	14. 8	68, 762	11	16. 0
10-19.....	146, 729	9	6. 1	15, 665	1	6. 4	21, 275	1	4. 7	109, 789	7	6. 4
20 and over.....	599, 593	15	2. 5	404, 528	14	3. 5	77, 860	1	1. 3	117, 205	0	0
<i>White</i>												
All ages.....	610, 608	49	8. 0	305, 876	25	8. 2	56, 468	7	12. 4	248, 264	17	6. 8
0-4.....	54, 897	26	47. 4	8, 784	12	136. 6	9, 332	7	75. 0	36, 781	7	19. 0
5-9.....	49, 303	9	18. 3	2, 958	4	135. 2	2, 465	0	0	43, 880	5	11. 4
10-19.....	90, 635	5	5. 5	7, 251	0	0	7, 251	0	0	76, 133	5	6. 6
20 and over.....	415, 773	9	2. 2	286, 882	9	3. 1	37, 420	0	0	91, 470	0	0
<i>Nonwhite</i>												
All ages.....	328, 416	48	14. 6	138, 588	21	15. 2	81, 699	14	17. 1	108, 129	13	12. 0
0-4.....	47, 712	26	54. 5	7, 634	11	144. 1	16, 222	10	61. 6	23, 856	5	21. 0
5-9.....	40, 790	12	29. 4	4, 895	4	81. 7	11, 013	2	18. 2	24, 882	6	24. 1
10-19.....	56, 094	4	7. 1	8, 414	1	11. 9	14, 024	1	7. 1	33, 656	2	5. 9
20 and over.....	183, 820	6	3. 3	117, 645	5	4. 3	40, 440	1	2. 5	25, 735	0	0

¹ Per 100,000 population.

the pure bulbar (only cranial nerve involvement, several of which were facial nerve palsies) and pure spinal. The overall paralytic fatality ratio of 6.2 percent is similar to that of 7.2 seen in the severe Baltimore epidemic of 1944, whereas the milder outbreaks in 1941 and 1950 showed ratios of only 3.0 percent and 2.8 percent, respectively (1). The paralytic fatality ratio for the entire United States in 1960 was given as 9.5 percent by the Communicable Disease Center (19).

In spite of the interpretive difficulties inherent in such descriptive data, the Baltimore epidemic was clearly of at least moderate severity and showed an unusual amount of bulbar disease.

Vaccine Effectiveness

Using data on the vaccination status of Baltimore residents during 1960 obtained on a sampling basis by the Baltimore health survey (20), attack rates by age group were estimated

for three or more, one or two, and no Salk vaccinations (table 6). The extremely high rates, well over 100 per 100,000, for unvaccinated preschool children of both races are immediately apparent. The rates declined with increasing numbers of inoculations as well as with increasing age. The crude effectiveness ratio computed from the vaccinated and unvaccinated rates in the highest risk age group (under 5 years) is 86.5 percent for three or more inoculations. The effectiveness ratio declines as age increases: 77 percent for the group 5-9 years, 60.1 percent for the group 10-19 years, and so on. The small number of cases in the older age groups makes such figures less meaningful, but there is little doubt that the vaccine was effective in the high-risk preschool age group.

Discussion

The epidemiologic data show clearly that the paralytic poliomyelitis outbreak in Baltimore in 1960 was localized to the preschool, unvac-

cinated, nonwhite, inner city, and lower socioeconomic groups. The pattern agrees with the urban epidemic picture noted consistently in the United States since 1955 (5-11), all but one of the other epidemics being type 1. For Baltimore City, it represented a change to greater involvement of nonwhites in comparison with the epidemics of 1941, 1944, 1950, and 1953.

On the question of whether type 3 poliovirus produces more severe disease and higher incidence of bulbar involvement than other poliovirus types, the Baltimore epidemic offered these findings: The paralytic fatality ratio was similar to that of its acknowledgedly severe predecessor in 1944, and the percentages of both cranial nerve involvement and respiratory failure were higher than usually seen (18). Most of the cases of respiratory failure were treated at Baltimore City Hospitals with advanced methods of tracheotomy and respirator management, which may well have reduced the death rate (21). It is difficult, however, to demonstrate that these characteristics were a function of poliovirus type. Both cranial nerve involvement and respiratory failure were greater than in Washington, D.C., in 1957, the next largest urban type 3 outbreak recently studied in this country (5). On the other hand, a high incidence of cranial nerve involvement (37 percent) and a high paralytic fatality ratio (7 percent) were also seen in the Providence, R.I., epidemic of 1960 (11), which was due predominantly to type 1 poliovirus.

It does not seem, therefore, that at present any clearly predictable pattern of severity or clinical syndrome can be correlated with poliovirus type. It is known that epidemics vary in severity (for example, in Baltimore from 1935 to 1960), percentage of bulbar involvement—a range of 2.5 to 100 percent in one review (22)—and age distribution. It is also known that each virus type varies in antigenicity and virulence from strain to strain (23, 24). As the combined epidemiologic and virologic study of poliomyelitis epidemics and further correlative studies are completed, it should be possible to assess more clearly the degree of association between virus type and epidemic behavior.

There was no marked indication, as was seen in Massachusetts in 1959, that the Salk vaccine was significantly less effective for type 3 polio-

virus. In 1960, when national vaccine effectiveness was estimated at 91 percent for the age group 0-4 years (against all three virus types) for three or more doses (25), a similarly computed estimate for Baltimore's predominantly type 3 outbreak was 86.5 percent for children under 5 years (three or more doses). For older age groups, the effectiveness ratio estimate was much lower, but these values are relatively meaningless because of the small numbers of cases. Also because of the small numbers of cases and because of imprecise data on the years in which vaccinations were performed, no attempt was made to relate degree of protection to the year of vaccination. It seemed evident that the protective value of the vaccine against type 3 paralytic disease was amply demonstrated in the high-risk preschool age group.

Summary

In 1960, Baltimore experienced an epidemic of paralytic poliomyelitis due predominantly to type 3 poliovirus. It was the first large outbreak of poliomyelitis in the city since the introduction of mass immunization and the largest known type 3 urban epidemic reported in this country to date.

The epidemic was localized to the younger age groups (particularly preschool children), nonwhites, the unvaccinated, and the socioeconomically deprived areas of the inner city. The clinical syndrome was characterized by a high percentage of both cranial nerve involvement and respiratory failure. The paralytic case fatality ratio was 6.2 percent.

Comparison of the epidemic characteristics with those of other outbreaks in which the predominant causative poliovirus type was known failed to show any clearly predictable pattern of epidemic behavior that could be correlated with poliovirus type. There was no marked indication that the Salk vaccine was less effective in protecting against type 3 paralytic disease.

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Group Health Institute

The 12th annual Group Health Institute, sponsored by the Group Health Association of America, Inc., will be held May 14-16, 1962, in Washington, D.C. The institute is being held in conjunction with the annual meeting of the GHAA, which recently moved its headquarters to Washington from Chicago.

The main theme of the institute will be "Achieving Better Health Through Group Practice Prepayment."

Further information regarding the program and advance registration is available from: Group Health Institute, % Group Health Association, Inc., Frank J. Morris, 1025 Vermont Ave. NW., Washington 5, D.C.